

Ocean Heat and Freshwater Content Variability Estimates

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1. PROJECT SUMMARY

When people speak of climate they are often referring to the climate of the atmosphere at the earth's surface. This is where humankind lives and it is only natural to be concerned about the immediate space that humankind inhabits. However, in order to understand the working's of earth's climate system, and to be able to forecast changes in earth's climate system, we need to study all components of earth's climate system including the atmosphere, the world ocean, the cryosphere (earth's ice such as continental ice sheets and mountain glaciers), the lithosphere (earth's continents) and the biosphere. Each of the components of the climate system except for the biosphere can store heat and the ocean, atmosphere, and even the cryosphere can transport heat. Both the storage and transport of heat are important processes that maintain our climate system. The biosphere does not store substantial amounts of heat but it can affect how much heat is stored within each components of earth's climate system.

Rossby (1959) suggested that the world ocean may be the dominant component of the earth's heat balance on interannual- to-decadal- time scales. Rossby did not discuss what we now term "anthropogenic" or "human-induced" warming of earth's climate system. Recent work (Levitus *et al.* 2000, 2001, 2005) has shown Rossby to be correct. Ishii *et al.* have duplicated these first estimates of the temporal variability of earth's heat content.

During 1955-98 the world ocean (0-3000 m depth) warmed and accounted for more than 80% of the increase in the earth system's heat content. The heat content of the world is now recognized as being a critical variable to describe the earth's climate system. Increasing greenhouse gases will result in an increase of the heat content of the earth system with most of the warming occurring in the world ocean. During 1955-2003 the upper 700 m has warmed but during 2004-2005 this layer of the world ocean cooled.

The NODC Ocean Climate Laboratory (OCL) has provided international leadership in the development of ocean profile databases to provide the data used to make the first estimates of ocean heat content (OHC) during the 1955-present period. Sydney Levitus is Leader of the IOC Global Oceanographic Data Archaeology and Rescue project (Levitus *et al.*, 2004a). This project has resulted in a doubling of historical ocean temperature profiles for the pre-1991 period. Our work is exemplary of the bullet in the Summary of user recommendation for observing system enhancements from the 2004 Annual System Review which is "Build the ocean profile database necessary to compute ocean heat content".

Our work on OHC has attracted considerable attention from the scientific community, Congress, and the media.

Our work has been used in IPCC Assessments most recently in the IPCC 2007 Assessment. The IPCC has received the Nobel Peace Prize for 2007. Our work has also been used in an NRC Report to President Bush.

2. ACCOMPLISHMENTS

During FY08 the P.I. and his colleagues focused on correcting historical and modern data for recently discovered systematic errors in bathythermograph (BT) data. Figure 1 is an example of our most recent work and shows the time series of OHC for the 0-700 m layer of the world ocean through the end of 2007. After reaching a relative maximum in heat content during 2003, world ocean heat content has approximately stayed level. Correction of the biases in BT data results in a reduction of the interdecadal variability.

A major goal of this proposal has been to prepare estimates of ocean heat content every three months and make them available online. This had to be delayed because of the discovery of systematic time-varying errors in the drop rates of XBTs and MBTs and in biases found in profiling floats (PFL). We have corrected for these biases and have begun generating seasonal OHC estimates. Figure 2 shows the time series of seasonal estimates for 1955-2007. These seasonal estimates also appear in Figure 3 with each season plotted separately.

The P.I. was a Lead Author of the IPCC (2007) assessment of earth's climate system. The work published by the P.I. and his colleagues plays a prominent role in Chapter 5 of the IPCC (2007) climate change assessment which was awarded a Nobel Peace Prize.

All of our data are made available within three months of receipt at the NODC Home Page (www.nodc.noaa.gov).

3. PUBLICATIONS AND REPORTS

Levitus, S., J. I. Antonov, T. P. Boyer, 2005: Warming of the World Ocean, 1955-2007. *Geophys. Res. Lett.*, in preparation.

4. FIGURES

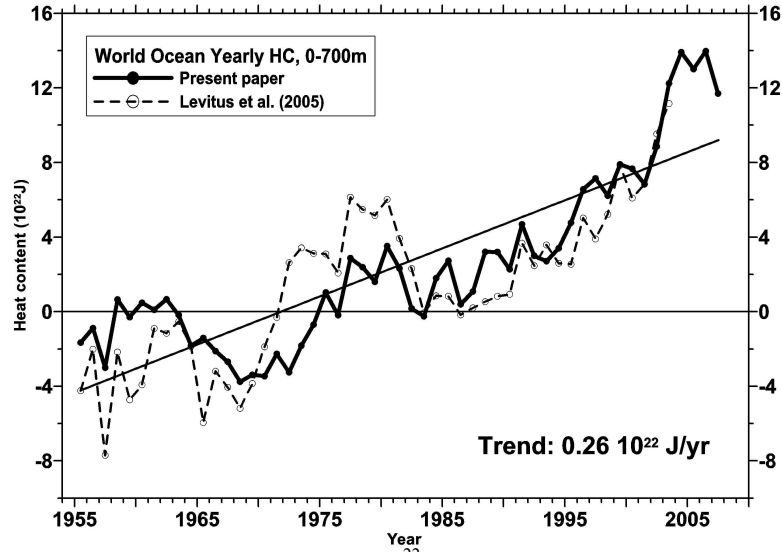


Figure 1. Time series of yearly ocean heat content (10^{22} J) for the 0-700 m layer from this study (solid) and from Levitus *et al.* (2005) (dashed). Each yearly estimate is plotted at the midpoint of the year.

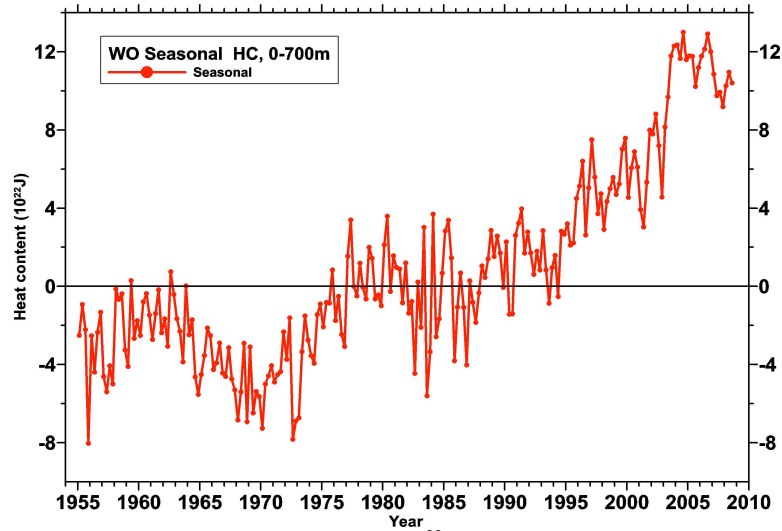


Figure 2. Time series of seasonal ocean heat content (10^{22} J) for 0-700 for 1955-2008.

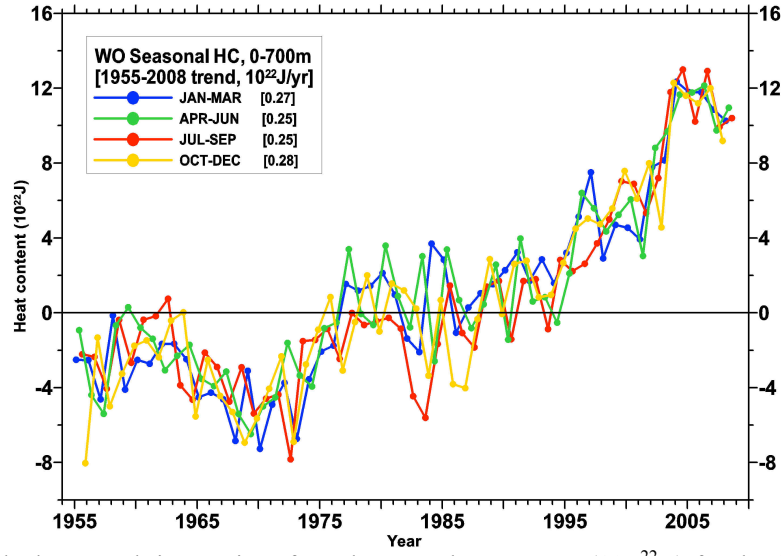


Figure 3. Individual seasonal time series of yearly ocean heat content ($10E^{22}$ J) for the 0-700 m from this study and their trends for 1955-2008.